Horsepower

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A team of six horses mowing hay in Lancaster County, Pennsylvania

Horsepower (**hp**) is a unit of measurement of power (the rate at which work is done). There are many different standards and types of horsepower. Two common definitions in use today are the **mechanical horsepower** (or **imperial horsepower**), which for example is approximately 745.7 watts and the **metric horsepower**, which is approximately 735.5 watts.

The term was adopted in the late 18th century by Scottish engineer James Watt to compare the output of steam engines with the power of draft horses. It was later expanded to include the output power of other types of piston engines, as well as turbines, electric motors and other machinery.[1][2] The definition of the unit varied between geographical regions. Most countries now use the SI unit *watt* for measurement of power. With the implementation of the EU Directive 80/181/EEC on January 1, 2010, the use of horsepower in the EU is permitted only as a supplementary unit.[3]

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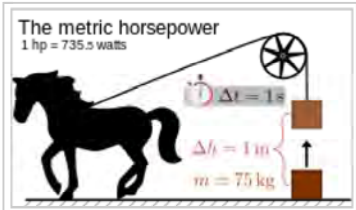
Definitions of term

Units called "horsepower" have differing definitions:



One *metric horsepower* is needed to lift 75 kilograms (avg. body weight of a person) by 1 meter (3.28 feet) in 1 second.

- The *mechanical horsepower*, also known as *imperial horsepower* equals approximately 745.7 watts. It was defined originally as exactly 550 foot-pounds per second).
- The *metric horsepower* equals approximately 735.5 watts (98.6% of an *imperial mechanical horsepower*). It was defined originally as 75 kgf-m per second is approximately equivalent to 735.5 watts.
  - The *Pferdestärke* PS (German translation of horsepower) is a name for a group of similar power measurements used in Germany around the end of the 19th century, all of about one metric horsepower in size.[4][5][6]
- The *boiler horsepower* equals 9809.5 watts. It was used for rating steam boilers and is equivalent to 34.5 pounds (about 15.6 kg) of water evaporated per hour at 212 degrees Fahrenheit (100 degrees Celsius).
- One horsepower for rating electric motors is equal to 746 watts.
- One horsepower for rating Continental European electric motors is equal to 735 watts. Continental European electric motors used to have dual ratings.
- One British Royal Automobile Club (RAC) horsepower can equal a range of values based on estimates of several engine dimensions. It is one of the tax horsepower systems adopted around Europe.

History of the unit

The development of the steam engine provided a reason to compare the output of horses with that of the engines that could replace them. In 1702, Thomas Savery wrote in *The Miner's Friend*:

> So that an engine which will raise as much water as two horses, working together at one time in such a work, can do, and for which there must be constantly kept ten or twelve horses for doing the same. Then I say, such an engine may be made large enough to do the work required in employing eight, ten, fifteen, or twenty horses to be constantly maintained and kept for doing such a work…[7]

The idea was later used by James Watt to help market his improved steam engine. He had previously agreed to take royalties of one third of the savings in coal from the older Newcomen steam engines.[8] This royalty scheme did not work with customers who did not have existing steam engines but used horses instead.

Watt determined that a horse could turn a mill wheel 144 times in an hour (or 2.4 times a minute).[9] The wheel was 12 feet (3.7 m) in radius; therefore, the horse travelled 2.4 × 2π × 12 feet in one minute. Watt judged that the horse could pull with a force of 180 pounds-force (800 N). So:

$$P = \frac{W}{t} = \frac{Fd}{t} = \frac{180\,\mathrm{lbf} \times 2.4 \times 2\,\pi \times 12\,\mathrm{ft}}{1\,\mathrm{min}} = 32,572\frac{\mathrm{ft} \cdot \mathrm{lbf}}{\mathrm{min}}.$$

Watt defined and calculated the horsepower as 32,572 ft·lbf/min, which was rounded to an even 33,000 ft·lbf/min.[10]

Watt determined that a pony could lift an average 220 lbf (0.98 kN) 100 ft (30 m) per minute over a four-hour working shift.[11] Watt then judged a horse was 50% more powerful than a pony and thus arrived at the 33,000 ft·lbf/min figure.[12] *Engineering in History* recounts that John Smeaton initially estimated that a horse could produce 22,916 foot-pounds per minute. John Desaguliers had previously suggested 44,000 foot-pounds per minute and Tredgold 27,500 foot-pounds per minute. "Watt found by experiment in 1782 that a 'brewery horse' could produce 32,400 foot-pounds per minute." James Watt and Matthew Boulton standardized that figure at 33,000 the next year.[13]

Most observers familiar with horses and their capabilities estimate that Watt was either a bit optimistic or intended to underpromise and overdeliver; few horses can maintain that effort for long. Regardless, comparison with a horse proved to be an enduring marketing tool.

A common legend states that the unit was created when one of Watt's first customers, a brewer, specifically demanded an engine that would match a horse, but tried to cheat by taking the strongest horse he had and driving it to the limit. Watt, while aware of the trick, accepted the challenge and built a machine which was actually even stronger than the figure achieved by the brewer, and it was the output of that machine which became the horsepower.[14]

In 1993, R. D. Stevenson and R. J. Wassersug published an article calculating the upper limit to an animal's power output.[15] The peak power over a few seconds has been measured to be as high as 14.9 hp.[15] However, Stevenson and Wassersug observe that for sustained activity, a work rate of about 1 hp per horse is consistent with agricultural advice from both 19th and 20th century sources.[15]

When considering human-powered equipment, a healthy human can produce about 1.2 hp briefly (see orders of magnitude) and sustain about 0.1 hp indefinitely; trained athletes can manage up to about 2.5 hp briefly[16] and 0.3 hp for a period of several hours. The Jamaican sprinter Usain Bolt produced a maximum of 3.5 hp 0.89 seconds into his 9.58 second 100m dash world record in 2009.[17]

Calculating power

When torque T is in pound-foot units, rotational speed (N) is in rpm and power is required in horsepower:

$$P(\mathrm{hp}) = \frac{T\,\mathrm{ft}\cdot\mathrm{lbf}\times N\,\mathrm{rpm}}{5252}$$

The constant 5252 is the rounded value of (33,000 ft·lbf/min)/(2π rad/rev).

When torque T is in inch pounds:

$$P(\mathrm{hp}) = \frac{T\,\mathrm{in}\cdot\mathrm{lbf}\times N\,\mathrm{rpm}}{63{,}025}$$

The constant 63,025 is the approximation of

$$33{,}000\,\frac{\mathrm{ft}\cdot\mathrm{lbf}}{\mathrm{min}}\cdot\frac{12\,\frac{\mathrm{in}}{\mathrm{ft}}}{2\,\pi\mathrm{rad}}\approx 63{,}025.$$

If torque and rotational speed are expressed in coherent SI units, the power is calculated by ;

$$P = \tau\cdot\omega$$

where P is power in watts when τ is torque in newton-metres, and ω is angular speed in radians per second. When using other units or if the speed is in revolutions per unit time rather than radians, a conversion factor has to be included.

Current definitions

The following definitions have been widely used:

Mechanical horsepower hp(I)	≡ 33,000 ft lbf/min = 550 ft·lbf/s ≈ 17696 $lb \cdot ft^2/s^3$ = 745.69987158227022 W
Metric horsepower hp(M) - also *PS*, *cv*, *hk*, *pk*, *ks* or *ch*	≡ 75 $kg_f \cdot m/s$ ≡ 75 kg · 9.80665 m/s^2 · 1 m/s ≡ 735.49875 W
Electrical horsepower hp(E)	≡ 746 W
Boiler horsepower hp(S)	≡ 33,475 BTU/h = 9,812.5 W
Hydraulic horsepower	= flow rate (US gal/min) × pressure (psi) × 7/12,000 or = flow rate (US gal/min) × pressure (psi) / 1714 = 550 ft·lbf/s = 745.69987158227022 W
Air horsepower	= flow rate (cubic feet / minute) × pressure (inches water column) / 6,356 or = 550 ft·lbf/s = 745.69987158227022 W

In certain situations it is necessary to distinguish between the various definitions of horsepower and thus a suffix is added: hp(I) for mechanical (or imperial) horsepower, hp(M) for metric horsepower, hp(S) for boiler (or steam) horsepower and hp(E) for electrical horsepower.

Hydraulic horsepower is equivalent to mechanical horsepower. The formula given above is for conversion to mechanical horsepower from the factors acting on a hydraulic system.

Mechanical horsepower

Assuming the third CGPM (1901, CR 70) definition of standard gravity, g_n=9.80665 m/s^2, is used to define the pound-force as well as the kilogram force, and the international avoirdupois pound (1959), one mechanical horsepower is:

$$\begin{aligned}
1\ \text{hp} &\equiv 33{,}000\ \text{ft-lbf/min} && \text{by definition} \\
&= 550\ \text{ft·lbf/s} && \text{since } 1\ \text{min} = 60\ \text{s} \\
&= 550 \times 0.3048 \times 0.45359237\ \text{m·kg}_f\text{/s} && \text{since } 1\ \text{ft} = 0.3048\ \text{m and } 1\ \text{lb} = 0.45359237\ \text{kg} \\
&= 76.0402249068\ \text{kg}_f\text{·m/s} && \\
&= 76.0402249068 \times 9.80665\ \text{kg·m}^2\text{/s}^3 && \text{since } g = 9.80665\ \text{m/s}^2 \\
&= 745.69987158227022\ \text{W} && \text{since } 1\ \text{W} \equiv 1\ \text{J/s} = 1\ \text{N·m/s} = 1\ (\text{kg·m/s}^2)\text{·(m/s)}
\end{aligned}$$

Or given that 1 hp = 550 ft·lbf/s, 1 ft = 0.3048 m, 1 lbf ≈ 4.448 N, 1 J = 1 N·m, 1 W = 1 J/s: 1 hp ≈ 746 W

Metric horsepower (PS, cv, hk, pk, ks, ch)

The various units used to indicate this definition (*PS*, *cv*, *hk*, *pk*, *ks* and *ch*) all translate to *horse power* in English, so it is common to see these values referred to as *horsepower* or *hp* in the press releases or media coverage of the German, French, Italian, and Japanese automobile companies. British manufacturers often intermix metric horsepower and mechanical horsepower depending on the origin of the engine in question. Sometimes the metric horsepower rating of an engine is conservative enough so that the same figure can be used for both 80/1269/EEC with metric hp and SAE J1349 with imperial hp.

DIN 66036 defines one metric horsepower as the power to raise a mass of 75 kilograms against the earth's gravitational force over a distance of one metre in one second;[18] this is equivalent to 735.49875 W or 98.6% of an imperial mechanical horsepower.

In 1972, the PS was rendered obsolete by EEC directives, when it was replaced by the kilowatt as the official power measuring unit.[19] It is still in use for commercial and advertising purposes, in addition to the kW rating, as many customers are still not familiar with the use of kilowatts for engines.

Other names for the metric horsepower are the Dutch *paardenkracht* (pk), the French *cheval* (ch), the Portuguese *cavalo-vapor* (cv), the Russian Лошадиная сила (лс), the Swedish *hästkraft* (hk), the Finnish *hevosvoima* (hv), the Norwegian and Danish *hestekraft* (hk), the Hungarian *lóerő* (LE), the Czech *koňská síla* and Slovak *konská sila* (k or ks), the Bosnian/Croatian/Serbian *konjska snaga* (KS), the Bulgarian Конска сила, the Macedonian Коњска сила (KC), the Polish *koń mechaniczny* (KM), Slovenian *konjska moč* (KM) and the Romanian *cal-putere* (CP), which all equal the German *Pferdestärke* (PS).

In the 19th century, the French had their own unit, which they used instead of the CV or horsepower. It was called the poncelet and was abbreviated *p*.

French and Italian tax horsepower (CV)

In addition, the capital form *CV* is used in Italy and France as a unit for tax horsepower, short for, respectively, *cavalli vapore* and *chevaux vapeur* (*steam horses*). CV is a non-linear rating of a motor vehicle for tax purposes.[20] The CV rating, or fiscal power, is $\left(\frac{P}{40}\right)^{1.6} + \frac{U}{45}$, where *P* is the maximum power in kilowatts and *U* is the amount of carbon dioxide (CO_2) emitted in grams per kilometre. The term for CO_2 measurements has been included in the definition only since 1998, so older ratings in CV are not directly comparable. The fiscal power has found its way into naming of automobile models, such as the popular Citroën deux-chevaux. The *cheval-vapeur* (ch) unit should not be confused with the French *cheval fiscal* (CV).

Electrical horsepower

The horsepower used for electrical machines is defined as exactly 746 W.[21] In the US, nameplates on electrical motors show their power output in hp, not their power input. Outside the United States watts or kilowatts are generally used for electric motor ratings and in such usage it is the output power that is stated.

Hydraulic horsepower

Hydraulic horsepower can represent the power available within hydraulic machinery, power through the down-hole nozzle of a drilling rig,[22] or can be used to estimate the mechanical power needed to generate a known hydraulic flow rate.

It may be calculated as:[22]

$$Hydraulic\ horsepower = \frac{Pressure \times Flowrate}{1714}$$

Pressure is in psi
Flow rate is in US gallons per minute

Drilling rigs are powered mechanically by rotating the drill pipe from above. Hydraulic power is still needed though, as between 2 and 7 hp are required to push mud through the drill bit in order to clear waste rock. This hydraulic power, considerably more than this, may also be used to drive a down-hole mud motor to power directional drilling.[22]

Boiler horsepower

Boiler horsepower is a boiler's capacity to deliver steam to a steam engine and is not the same unit of power as the 550 ft-lb/s definition. One boiler horsepower is equal to the thermal energy rate required to evaporate 34.5 lb of fresh water at 212 °F in one hour. In the early days of steam use, the boiler horsepower was roughly comparable to the horsepower of engines fed by the boiler.[23]

The term "boiler horsepower" was originally developed at the Philadelphia Centennial Exhibition in 1876, where the best steam engines of that period were tested. The average steam consumption of those engines (per output horsepower) was determined to be the evaporation of 30 pounds of water per hour, based on feed water at 100 °F, and saturated steam generated at 70 psig. This original definition is equivalent to a boiler heat output of 33,485 Btu/hr. Years later in 1884, the ASME re-defined the boiler horsepower as the thermal output equal to the evaporation of 34.5 pounds per hour of water "from and at" 212 °F. This considerably simplified boiler testing, and provided more accurate comparisons of the boilers at that time. This revised definition is equivalent to a boiler heat output of 33,469 Btu/hr. Present industrial practice is to define "boiler horsepower" as a boiler thermal output equal to 33,475 Btu/hr, which is very close to the original and revised definitions.

Boiler horsepower is still used to measure boiler output in industrial boiler engineering in Australia, the US, and New Zealand. Boiler horsepower is abbreviated BHP, not to be confused with brake horsepower, below, which is also called BHP.

Drawbar horsepower

Drawbar horsepower (dbhp) is the power a railway locomotive has available to haul a train or an agricultural tractor to pull an implement. This is a measured figure rather than a calculated one. A special railway car called a dynamometer car coupled behind the locomotive keeps a continuous record of the drawbar pull exerted, and the speed. From these, the power generated can be calculated. To determine the maximum power available, a controllable load is required; it is normally a second locomotive with its brakes applied, in addition to a static load.

If the drawbar force (F) is measured in pounds-force (lbf) and speed (v) is measured in miles per hour (mph), then the drawbar power (P) in horsepower (hp) is:

$$P/\mathrm{hp} = \frac{(F/\mathrm{lbf})(v/\mathrm{mph})}{375}$$

Example: How much power is needed to pull a drawbar load of 2,025 pounds-force at 5 miles per hour?

$$P/\mathrm{hp} = \frac{2025 \times 5}{375} = 27$$

The constant 375 is because 1 hp = 375 lbf·mph. If other units are used, the constant is different. When using coherent SI units (watts, newtons, and metres per second), no constant is needed, and the formula becomes $P = Fv$.

This formula may also be used to calculate the horsepower of a jet engine, using the speed of the jet and the thrust required to maintain that speed.

Example: How much power is generated with a thrust of 4,000 pounds at 400 miles per hour?

$$P/\mathrm{hp} = \frac{4000 \times 400}{375} = 4266.666666666667$$

RAC horsepower (taxable horsepower)

This measure was instituted by the Royal Automobile Club in Britain and was used to denote the power of early 20th-century British cars. (An identical measure, known as ALAM horsepower or NACC horsepower, was used for early U.S. automobiles.) Many cars took their names from this figure (hence the Austin Seven and Riley Nine), while others had names such as "40/50 hp", which indicated the RAC figure followed by the true measured power.

Taxable horsepower does not reflect developed horsepower; rather, it is a calculated figure based on the engine's bore size, number of cylinders, and a (now archaic) presumption of engine efficiency. As new engines were designed with ever-increasing efficiency, it was no longer a useful measure, but was kept in use by UK regulations which used the rating for tax purposes.

$$\text{RAC h.p.} = \frac{2}{5} D^2 n$$

where

D is the diameter (or bore) of the cylinder in inches
n is the number of cylinders [24]

This is equal to the engine displacement in cubic inches divided by 0.625π then divided again by the stroke in inches.

Since taxable horsepower was computed based on bore and number of cylinders, not based on actual displacement, it gave rise to engines with 'undersquare' dimensions (bore smaller than stroke) this tended to impose an artificially low limit on rotational speed (rpm), hampering the potential power output and efficiency of the engine.

The situation persisted for several generations of four- and six-cylinder British engines: for example, Jaguar's 3.4-litre XK engine of the 1950s had six cylinders with a bore of 83 mm (3.27 in) and a stroke of 106 mm (4.17 in),[25] where most American automakers had long since moved to oversquare (large bore, short stroke) V-8s (see, for example, the early Chrysler Hemi).

Measurement

The power of an engine may be measured or estimated at several points in the transmission of the power from its generation to its application. A number of names are used for the power developed at various stages in this process, but none is a clear indicator of either the measurement system or definition used.

In the case of an engine dynamometer, power is measured at the engine's flywheel. Also, with a chassis dynamometer or *rolling road*, power output is measured at the driving wheels. This accounts for energy or power loss through the drive train inefficiencies and weight thereof as well as gravitational force placed upon components therein.

In general:

Nominal or rated horsepower is derived from the size of the engine and the piston speed and is only accurate at a pressure of 48 kPa (7 psi).[26]

Indicated or gross horsepower (theoretical capability of the engine) [PLAN/ 33000]

minus frictional losses within the engine (bearing drag, rod and crankshaft windage losses, oil film drag, etc.), equals

Brake / net / crankshaft horsepower (power delivered directly to and measured at the engine's crankshaft)

minus frictional losses in the transmission (bearings, gears, oil drag, windage, etc.), equals

Shaft horsepower (power delivered to and measured at the output shaft of the transmission, when present in the system)

minus frictional losses in the universal joint/s, differential, wheel bearings, tire and chain, (if present), equals

Effective, True (thp) or commonly referred to as wheel horsepower (whp)

All the above assumes that no power inflation factors have been applied to any of the readings.

Engine designers use expressions other than horsepower to denote objective targets or performance, such as brake mean effective pressure (BMEP). This is a coefficient of theoretical brake horsepower and cylinder pressures during combustion.

Nominal (or rated) horsepower (nhp or rhp)

Nominal horsepower (nhp) is an early 19th-century rule of thumb used to estimate the power of steam engines.[26]

nhp = 7 x area of piston x equivalent piston speed/33,000

For paddle ships the piston speed was estimated as 129.7 x $(\text{stroke})^{1/3.35}$.[26]

The stroke was the distance moved by the piston.

For the nominal horsepower to equal the actual power it would be necessary for the mean steam pressure in the cylinder during the stroke to be 48 kPa (7 psi) and for the piston speed to be of the order of 54–75 m/min.[26]

The French Navy used the same definition of nominal horse power as Britain.[26]

Indicated horsepower (ihp)

Indicated horsepower (ihp) is the theoretical power of a reciprocating engine if it is completely frictionless in converting the expanding gas energy (piston pressure × displacement) in the cylinders. It is calculated from the pressures developed in the cylinders, measured by a device called an *engine indicator* – hence indicated horsepower. As the piston advances throughout its stroke, the pressure against the piston generally decreases, and the indicator device usually generates a graph of pressure vs stroke within the working cylinder. From this graph the amount of work performed during the piston stroke may be calculated.

Indicated horsepower was a better measure of engine power than nominal horsepower (nhp) because it took account of steam pressure. But unlike later measures such as shaft horsepower (shp) and brake horsepower (bhp), it did not take into account power losses due to the machinery internal frictional losses, such as a piston sliding within the cylinder, plus bearing friction, transmission and gear box friction, etc.

Brake horsepower (bhp)

It is horsepower measured at the crankshaft just outside the engine, before the losses of power caused by the gearbox and drive train.

In Europe, the DIN standard tested the engine fitted with all ancillaries and exhaust system as used in the car. The older American standard (SAE gross horsepower, referred to as bhp) used an engine without alternator, water pump, and other auxiliary components such as power steering pump, muffled exhaust system, etc., so the figures were higher than the European figures for the same engine. The newer American standard (referred to as SAE net horsepower, not as bhp) tests an engine with all the auxiliary components (see "Engine power test standards" below).

Brake refers to the device which was used to load an engine and hold it at a desired rotational speed. During testing, the output torque and rotational speed were measured to determine the brake horsepower. Horsepower was originally measured and calculated by use of the "indicator diagram" (a James Watt invention of the late 18th century), and later by means of a Prony brake connected to the engine's output shaft. More recently, an electrical brake dynamometer is used instead of a Prony brake. Although the output delivered to the drive wheels is less than that obtainable at the engine's crankshaft, use of a chassis dynamometer gives an indication of an engine's "real world" horsepower after losses in the drive train and gearbox.

Shaft horsepower (shp)

Shaft horsepower (shp) is the power delivered to a propeller shaft, a turbine shaft — or to an output shaft of an automotive transmission.[27] This shaft horsepower can be measured with a torque (torsion) meter, or estimated from the horsepower at the crankshaft and a standard figure for the losses in the transmission (typical figures are around 10%). Shaft horsepower is not commonly used in the internal-combustion-engine automobile industry because of the need to estimate losses in the transmission; instead, this industry in the USA typically uses SAE certified net power, which is measured at the engine's crankshaft, and so does not account for losses in the transmission (see "Engine power test standards", below).

Wheel horsepower (whp)

Motor vehicle dynamometers can measure wheel horsepower, which is the effective, true horsepower delivered to the driving wheel(s), representing the actual power available to accelerate the vehicle after all losses in the drive train, and all parasitic losses such as pumps, fans, alternator, muffled exhaust, etc. The vehicle is generally attached to the dynamometer and accelerates a large roller and Power Absorbing Unit which is driven by the vehicle's drive wheel(s). The actual power is then computer calculated based on the rotational inertia of the roller, its resultant acceleration rates and power applied by the Power Absorbing Unit. Some motor vehicle (and motorbike) dynamometers can also be purely inertia-based where the power output is calculated from measuring the acceleration of a roller drum with a known rotational inertia and known parasitic frictional losses of the roller drum's bearings.

Engine power test standards

There exist a number of different standard determining how the power and torque of an automobile engine is measured and corrected. Correction factors are used to adjust power and torque measurements to standard atmospheric conditions, to provide a more accurate comparison between engines as they are affected by the pressure, humidity, and temperature of ambient air.[28] Some standards are described below.

Society of Automotive Engineers/SAE International

Early "SAE horsepower" (see RAC horsepower)

In the early twentieth century, a so-called "SAE horsepower" was sometimes quoted for U.S. automobiles. This long predates the SAE horsepower measurement standards and was really just another term for the widely used ALAM or NACC horsepower figure, which was the same as the British RAC horsepower, used for tax purposes.

SAE gross power

Prior to the 1972 model year, American automakers rated and advertised their engines in brake horsepower, *bhp*, which was a version of brake horsepower called SAE gross horsepower because it was measured according to SAE standards (J245 and J1995) that call for a stock test engine without accessories (such as dynamo/alternator, radiator fan, water pump),[29] and sometimes fitted with long tube test headers in lieu of the OEM exhaust manifolds. The atmospheric correction standards for barometric pressure, humidity and temperature for testing were relatively idealistic.

SAE net power

In the United States, the term *bhp* fell into disuse in 1971–1972, as automakers began to quote power in terms of SAE net horsepower in accord with SAE standard J1349. Like SAE gross and other brake horsepower protocols, SAE Net hp is measured at the engine's crankshaft, and so does not account for transmission losses. However, the SAE net power testing protocol calls for standard production-type belt-driven accessories, air cleaner, emission controls, exhaust system, and other power-consuming accessories. This produces ratings in closer alignment with the power produced by the engine as it is actually configured and sold.

SAE certified power

In 2005, the SAE introduced "SAE Certified Power" with SAE J2723.[30] This test is voluntary and is in itself not a separate engine test code but a certification of either J1349 or J1995 after which the manufacturer is allowed to advertise "Certified to SAE J1349" or "Certified to SAE J1995" depending on which test standard have been followed. To attain certification the test must follow the SAE standard in question, take place in an ISO9000/9002 certified facility and be witnessed by an SAE approved third party.

A few manufacturers such as Honda and Toyota switched to the new ratings immediately, with multi-directional results; the rated output of Cadillac's supercharged Northstar V8 jumped from 440 to 469 hp (328 to 350 kW) under the new tests, while the rating for Toyota's Camry 3.0 L *1MZ-FE* V6 fell from 210 to 190 hp (160 to 140 kW). The company's Lexus ES 330 and Camry SE V6 were previously rated at 225 hp (168 kW) but the ES 330 dropped to 218 hp (163 kW) while the Camry declined to 210 hp (160 kW). The first engine certified under the new program was the 7.0 L LS7 used in the 2006 Chevrolet Corvette Z06. Certified power rose slightly from 500 to 505 hp (373 to 377 kW).

While Toyota and Honda are retesting their entire vehicle lineups, other automakers generally are retesting only those with updated powertrains. For example, the 2006 Ford Five Hundred is rated at 203 horsepower, the same as that of 2005 model. However, the 2006 rating does not reflect the new SAE testing procedure, as Ford is not going to incur the extra expense of retesting its existing engines. Over time, most automakers are expected to comply with the new guidelines.

SAE tightened its horsepower rules to eliminate the opportunity for engine manufacturers to manipulate factors affecting performance such as how much oil was in the crankcase, engine control system calibration, and whether an engine was tested with premium fuel. In some cases, such can add up to a change in horsepower ratings. A road test editor at Edmunds.com, John Di Pietro, said decreases in horsepower ratings for some 2006 models are not that dramatic. For vehicles like a midsize family sedan, it is likely that the reputation of the manufacturer will be more important.[31]

Deutsches Institut für Normung 70020

DIN 70020 is a standard from German DIN regarding road vehicles. DIN testing, unlike SAE gross power testing, tested the engine as installed in the vehicle, with cooling system, charging system and stock exhaust system all connected. Because the German word for *horsepower* is ***P****ferde**s**tärke*, in Germany it is commonly abbreviated to *PS*. DIN hp is measured at the engine's output shaft, and is usually expressed in metric (Pferdestärke) rather than mechanical horsepower.

CUNA

A test standard by Italian CUNA (*Commissione Tecnica per l'Unificazione nell'Automobile*, Technical Commission for Automobile Unification), a federated entity of standards organisation UNI, was formerly used in Italy. CUNA prescribed that the engine be tested with all accessories necessary to its running fitted (such as the water pump), while all others—such as alternator/dynamo, radiator fan, and exhaust manifold—could be omitted.[29] All calibration and accessories had to be as on production engines.[29]

Economic Commission for Europe R24

ECE R24 is a UN standard for the approval of compression ignition engine emissions, installation and measurement of engine power.[32] It is similar to DIN 70020 standard, but with different requirements for connecting an engine's fan during testing causing it to absorb less power from the engine.[33]

Economic Commission for Europe R85

ECE R85 is a UN standard for the approval of internal combustion engines with regard to the measurement of the net power.[34]

80/1269/EEC

80/1269/EEC of 16 December 1980 is a European Union standard for road vehicle engine power.

International Organization for Standardization

- ISO 14396 specifies the additional and method requirement for determining the power of reciprocating internal combustion engines when presented for an ISO 8178 exhaust emission test. It applies to reciprocating internal combustion engines for land, rail and marine use excluding engines of motor vehicles primarily designed for road use.[35]
- ISO 1585 is an engine net power test code intended for road vehicles.[36]
- ISO 2534 is an engine gross power test code intended for road vehicles.[37]
- ISO 4164 is an engine net power test code intended for mopeds.[38]
- ISO 4106 is an engine net power test code intended for motorcycles.[39]
- ISO 9249 is an engine net power test code intended for earth moving machines.[40]

Japanese Industrial Standard D 1001

JIS D 1001 is a Japanese net, and gross, engine power test code for automobiles or trucks having a spark ignition, diesel engine, or fuel injection engine.[41]

See also

- Brake specific fuel consumption—how much fuel an engine consumes per unit energy output
- European units of measurement directives
- Mean effective pressure
- Horsepower-hour
- Torque

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External links

- How Stuff Works - Horsepower (http://auto.howstuffworks.com/horsepower.htm)

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